Vol. XII. No. 4. April 15, 1915

THE

PSYCHOLOGICAL BULLETIN

GENERAL REVIEWS AND SUMMARIES

THE AUTONOMIC NERVOUS SYSTEM

BY F. W. CARPENTER

Trinity College, Hartford, Conn.

I. General Structure and Functions

Langley's term, "autonomic nervous system," has become widely adopted for designating all that portion of the peripheral nervous mechanism not included in the cerebro-spinal system of nerves. The latter supplies the organs of special sense and the voluntary muscles of the body, and through it we deal more or less consciously with the external world. The autonomic system, on the other hand, exercises control of the so-called vegetative processes of the body, and since it performs its functions with a certain independence of the brain, and even, in some cases, of the spinal cord, the name proposed by Langley is not an inappropriate one.

It is manifestly impossible to summarize at all adequately our present knowledge of the autonomic system in the space here available. Moreover, especially in respect to the functional side, the writer, whose training has been morphological rather than physiological, is aware of his own limitations. An attempt will be made merely to indicate a number of the more salient features of the modern conception of the system which enables us to understand it to some extent as a working mechanism. For this purpose it will be convenient to follow Langley's nomenclature, and consider in turn the four components or divisions of the system recognized by him, namely, the sympathetic, the sacral autonomic, the cranial autonomic, and the enteric.

Sympathetic.—Of the various divisions of the autonomic system

that known as the sympathetic proper is the largest and most familiar. The term is, indeed, often extended to cover the entire autonomic system. As here understood, however, it is applicable only to those autonomic fibers which arise from the thoracico-lumbar regions of the spinal cord together with the neurones which continue the paths of these fibers. The sympathetic is, therefore, the middle segment of the autonomic system, the other divisions arising from those portions of the central nervous axis above and below it.

The arrangement of the neurones comprising the sympathetic is typical for the entire autonomic system. The path of the impulses from the spinal cord to the organs innervated is made up of two sets or orders of neurones, one proximal and the other peripheral. The first neurones have their cell-bodies in the spinal cord, where they are situated, according to most observers, in the lateral region of the gray substance. Their axones pass outward in the ventral roots of the spinal nerves, and reach, via the white rami communicantes, the ganglia of the longitudinal sympathetic trunks (vertebral ganglia). Here some end in synapses (pericellular nets) around the cell-bodies of neurones of the second order, while others pass on to terminate in a similar way in more distant ganglia, such as those found in the solar plexus (prevertebral ganglia). Still others of these proximal axones may extend even farther, and reach the scattered and often poorly defined ganglia embedded in the walls of various thoracic and abdominal viscera (peripheral ganglia). None of these first or proximal neurones are themselves believed to reach the peripheral tissues activated by the sympathetic system. All end somewhere in synapses on peripheral nerve cells; hence the name, preganglionic fibers, applied to their axones by Langley.

The peripheral or postganglionic neurones which continue the nervous pathways have their cell-bodies, as has been indicated, either in the ganglia of the sympathetic trunks or in more distant ganglia. These neurones are multipolar. Their dendrites are for the most part confined to the ganglia in which the related cell-bodies lie, but their axones pass beyond these limits, and are widely distributed to the various tissues and organs under sympathetic control. As the components of sympathetic nerves proper, many of the axones in question run directly to organs of the thoracic and abdominal cavities,—stomach, small and large intestines, lungs, heart, spleen, internal genital organs, thyroid and adrenal glands. Here they terminate on smooth muscle, including that of blood

vessels, and on glands (visceromotor, vasomotor, and secretory fibers). Other postganglionic fibers, on leaving the ganglia of the sympathetic trunks, run in the gray rami communicates to the spinal nerves and accompany the spinal fibers peripherally in the various branches of these nerves. Such sympathetic neurones are in this way distributed to the blood vessels of the trunk and limbs (vasoconstrictor and vasodilator fibers), and to the sweat glands and erector muscles of the hairs in the skin (secretory and pilomotor fibers).

Sympathetic pathways to the iris and to the skin, blood vessels, and glands of the head region are provided by the cervical sympathetic trunks and their cephalic extensions. The preganglionic axones concerned terminate in the superior cervical ganglion. The postganglionic fibers given off from this ganglion pass without interruption to the tissues innervated.

The sympathetic neurones thus far dealt with are all efferent in function. They are accompanied, however, by afferent fibers, the latter appearing to be fibers from spinal ganglia with sympathetic distribution. In other words they are the peripheral processes of neurones, the cell-bodies of which lie in the ganglia of the dorsal roots of the spinal nerves. The central processes of these neurones enter the spinal cord by way of the dorsal nerve roots, but their connections in the central nervous system are not well understood. The peripheral processes terminate in sensory endings in the field of sympathetic distribution. The existence of intrinsic afferent neurones in the sympathetic system—sensory neurones with their cell-bodies in vertebral or prevertebral ganglia—is still a debatable question.

Sacral Autonomic.—Separated from the sympathetic by a considerable interval another set of preganglionic fibers emerges from the cord farther backward, that is, from the sacral region. These fibers, passing outward in the roots of the second, third, and fourth sacral nerves, and relayed peripherally by postganglionic neurones, conduct impulses to the lower portions of the digestive tube, to the bladder and urethra, and to the external genital organs, thus invading a part of the territory covered by the sympathetic. To this segment of the autonomic system the name, sacral autonomic, is applied. The afferent components of the sacral division probably have the same structural relations as those of the sympathetic.

Cranial Autonomic.—Preganglionic fibers belonging to the auto-

nomic system arise from two regions of the brain stem, the midbrain and the medulla. In the cervical portion of the spinal cord no preganglionic fibers are given off in the roots of the spinal nerves. White rami communicantes are wholly lacking. Consequently the sympathetic system, which extends forward centrally only as far as the first thoracic nerves, is separated from the cranial autonomic along the central nervous axis by the entire extent of the cervical cord.

The preganglionic fibers of the midbrain autonomic run in the third cranial or oculomotor nerve to the ciliary ganglion in the orbit, and are relayed thence by postganglionic nerves, the axones of which constitute the short ciliary nerves, and innervate the ciliary muscle and the sphincter of the iris.

The preganglionic fibers from the medulla (bulbar autonomic) pass outward in the seventh, ninth, tenth, and eleventh cranial nerves. Those emerging in the seventh nerve are distributed to and end in the sphenopalatine, submaxillary, and sublingual ganglia of the head. From these relay stations postganglionic neurones continue the nervous pathways, passing from the sphenopalatine ganglion to the tear glands and nasal and buccal mucous membrane, and from the submaxillary and sublingual ganglia to the salivary glands of the same name. The preganglionic fibers of the ninth cranial nerve appear to terminate in the otic ganglion. The second neurones in the course of these fibers are distributed to the parotid salivary gland and elsewhere in the facial region.

A large and important component of the bulbar autonomic is found in the preganglionic neurones leaving the medulla via the tenth and eleventh cranial nerves. A few of these may have their terminal synapses in the jugular ganglion at the base of the tenth nerve; but at least the majority of the fibers course in the vagus to a wide distribution, reaching the digestive organs from œsophagus to the middle region of the colon, the respiratory organs, heart, pancreas, and kidneys, possibly also the liver. These preganglionic fibers of the vagus probably establish connections with the cells of small and loosely aggregated ganglia found in or near the organs supplied. The short postganglionic axones which complete the paths innervate involuntary muscle and glandular tissue (viscero-motor and secretory fibers).

With the efferent cranial autonomic neurones described above there are functionally associated afferent neurones comparable to those of the sympathetic system in that their cell-bodies are found

in cranial ganglia homologous with the dorsal root ganglia of the spinal nerves. The ganglia of the trigeminus and the vagus are the ones chiefly concerned in reflexes effected through cranial autonomic fibers.

Enteric.—The plexuses of Auerbach and Meissner (myenteric and submucous plexuses) in the walls of the digestive tube have been provisionally placed by Langley in a division by themselves under the name of the enteric system. This seems to him necessary in view of the uncertainty that exists regarding their relations to the sympathetic and cranial autonomic fibers distributed to the walls of the alimentary canal. It is an interesting fact that when the last mentioned fibers are cut, the usual movements of the digestive tube nevertheless continue, presumably under the influence of the local enteric system, which appears to function as an automatic reflex mechanism independently of the extrinsic fibers. Under normal conditions the latter may exercise a regulatory control only. On the assumption that no purely afferent neurones are present in the enteric system (a matter which is in dispute) motor reflexes taking place here have been explained by supposing that impulses may pass from the enteric epithelium along the axones of neurones usually efferent, and thence via the collaterals of these axones to the muscles concerned (axone-reflex of Langley).

Double Innervation and Antagonistic Action.—It is evident that the distribution of the sacral and cranial autonomic overlaps, in many parts of the body, that of the sympathetic. For this reason it has been proposed by Langley to designate the sacral and cranial autonomic fibers by the name of parasympathetic, since they terminate, broadly speaking, alongside those of the sympathetic system. The heart, for instance, is innervated both by the sympathetic and the cranial autonomic, fibers of the latter reaching it through the vagus. The distribution of the sympathetic is general throughout the length of the digestive tube; but in the region extending from the œsophagus to the middle colon there is an overlapping of vagus fibers, while the descending colon and rectum are supplied in part by sacral autonomic fibers. Not all portions of the body reached by the sympathetic exhibit this double innervation. There seems, for instance, to be no evidence that parasympathetic fibers contribute to the nerve supply of the adrenal glands or internal genital organs.

Physiological experimentation has shown that the action of

impulses transmitted by parasympathetic fibers is often antagonistic to that of impulses transmitted by sympathetic fibers, so that double innervation frequently carries the implication of opposite nervous influences. A well-known example of this is seen in the autonomic control of the heart. Stimulation of the sympathetic fibers leading to it quickens its action, while stimulation of its parasympathetic fibers (from the vagus) causes it to beat more slowly. There is good evidence that the vagus accelerates the peristaltic movements of the stomach and intestine, whereas the sympathetic splanchnic nerves have an inhibitory action.

Pharmacological studies on the action of drugs such as atropin, pilocarpin, adrenalin, etc., have furnished further evidence of the physiological dissimilarity of the sympathetic and parasympathetic nerve endings. A given drug may affect those of one set of autonomic fibers without influencing in any apparent way the endings of the other set.

Normal Stimuli for the Autonomic System.—The efferent autonomic nerve fibers are normally brought into a state of functional activity in a variety of ways.

1. This may be accomplished through the stimulation of sensory endings, somatic or visceral, followed by a reflex, as when warm air in contact with the skin sets up impulses in sensory cerebro-spinal nerves which pass to the central nervous system. These impulses return peripherally along the autonomic fibers to the sweat glands, and the latter respond by increased activity. Cold air in a similar way affects through the pilomotor fibers the erector muscles of the small hairs distributed over the body, and the result is seen in the so-called "goose flesh."

Attention may here be called to the way in which bodily pain influences reflexly the autonomic system. In the presence of severe pain the pupils dilate, the frequency of the heart beat is changed, the tears may flow, and the secretion of saliva may be increased. Pawlow has shown that both the movements and secretion of the stomach are inhibited. The source of the pain—whether in visceral or somatic regions of the body—seems immaterial. Consciousness is not a necessary factor in the reflexes.

2. Nervous activity may also be induced through the agency of internal secretions. A comparatively new field for physiological investigation has been opened by the appreciation of the fact that the products of such "ductless glands" as the thyroid and adrenals have specific effects upon the autonomic nervous mechanism. An

illustration is afforded by the susceptibility of the sympathetic system—but not the parasympathetic—to adrenalin or epinephrin, a constituent of the secretion of the adrenal glands. One effect of a surprisingly small amount of adrenalin in the blood is the sensitizing of the vasoconstrictor nerve endings so that the efferent impulses discharged cause the muscular coats of small arteries to contract vigorously, the result being an increase in blood pressure.

3. An intimate relation exists, furthermore, between certain mental states, especially emotions, and the activity of the autonomic nerves. While, unlike the cerebro-spinal system controlling the voluntary muscles, the autonomic gives little or no evidence of being subject to voluntary control, it responds in a striking manner to "stimuli" afforded by certain mental processes, chiefly those which are of an emotional nature. A variety of instances might be adduced. Thus it is well known that the mere sight of food will in a hungry person or dog cause a lively secretion of the salivary glands through "psychic" stimulation of the parasympathetic. Pawlow has obtained evidence that under such conditions not only do the salivary glands become active, but the gastric glands, through impulses from the vagi, also discharge their secretions. Cannon has determined through the use of Röntgen rays that the digestive movements of the cat's stomach and intestine cease when the animal shows signs of anxiety, rage, or distress. Pawlow has shown, furthermore, that in an angry animal the secretion of gastric juice stops even for hours at a time. It is a common observation that at the sight of an enemy the hair of many animals rises along the back as the result of stimulation of the pilomotor nerves.

If emotions are functions of the cerebrum, then the correlated nervous impulses must pass downward from the hemispheres through the brain stem and spinal cord to reach the autonomic nerves. Only thus can be brought about in distant parts of the body those changes which appear as the physical concomitants of the emotions. Of the exact paths—fiber tracts—followed by such impulses in their course through the central nervous system we know to-day practically nothing. Again, if nervous impulses which arouse in consciousness sensations of pain must reach the cerebral cortex to accomplish this, then afferent paths must connect the cortex with the visceral organs. It is an only too familiar experience that vaguely localized sensations of pain, often severe, result from certain forms of lesion in the viscera. However, the

intra-spinal and intra-cranial portions of these sensory paths are as imperfectly known as the corresponding efferent paths. It should be mentioned that Bechterew, through electrical stimulation of the cerebral cortex, has attempted to locate here centers for vegetative functions, including movements of the intestine, secretion of sweat, etc., but his results lack confirmation. The only autonomic centers in the brain which have been at all definitely made out, such as those for pupillary reflexes, salivary secretion, and vasoconstriction, are found in the brain stem (diencephalon, midbrain, and medulla).

II. Recent Contributions to the Physiology of the Autonomic System

"Emotional" Stimulation.—The excitatory influence of emotions on the sympathetic nerves supplying the adrenal glands, and the subsequent widespread effects of the adrenal secretions thus called forth, have been investigated during the last few years by W. B. Cannon and his collaborators. The results of these studies, which have a special claim to the interest of psychologists, are summarized and discussed in two recent papers by Cannon (8) and (9).

A starting point for the investigations in question is found in the artificial stimulation of the splanchnic nerves (sympathetic) which supply the adrenals. This induces secretory activity in the central or medullary portion of the glands. The result is an internal secretion of a specific substance (adrenalin or epinephrin), an increased amount of which can be detected in the blood following the application of the stimulus. To determine whether similar secretory impulses are aroused by natural events in an animal's life, Cannon and de la Paz (11) examined the blood of a cat which had been frightened by a barking dog. They obtained definite evidence of the presence of adrenalin. Blood from the same vein tested just before the excitement gave negative results. Strong stimulation of the sciatic (spinal) nerve of an anæsthetized animal, such as would cause severe pain if the animal were conscious, was found by Cannon and Hoskins (12) to induce a reflex which likewise excited the adrenal medulla to increased activity. The same result was obtained under conditions of asphyxia.

When the splanchnic nerves are stimulated artificially, not only is adrenalin liberated from the adrenal glands but sugar is also released from the liver. This increase in the amount of sugar in

the blood does not follow excitation of the splanchnics after removal of the adrenals from the body, a fact which seems to indicate that the glands play an essential rôle in occasioning the hyperglycæmia. Here, as in the case of adrenalin production alone, experimentation has proved that pure emotional excitement—fear or rage—has the same effect as direct stimulation of the sympathetic nerves. Cannon, Shohl and Wright (15) obtained glycosuria in excitable cats by simply fastening them in comfortable holders under conditions eliminating the possibility of pain, and also by allowing a dog to bark at them while they were confined in small cages. The glycosuria did not appear in excited animals after excision of the adrenals. Cannon (9) states in a footnote: "Mr. C. H. Fiske and I have found sugar in the urine in 12 of 25 members of the Harvard University foot-ball squad immediately after the final and most exciting contest of the season. Five of the positive cases were substitutes who were not called upon to enter the game. The only spectator whose urine was examined had a marked glycosuria."

That the liberation of sugar and adrenalin under conditions of pain and major emotions is of value to the organism as a whole seems clear. Sugar furnishes the muscles with energy; adrenalin causes them to respond more readily to nervous impulses, thus lessening the effect of fatigue. Adrenalin also, through inducing vasoconstriction in the organs of the abdominal cavity—intestines, spleen and kidneys—forces more blood into the muscular regions of the body.

Cannon (9) summarizes as follows his interesting conclusions regarding the value of emotional stimulation of the sympathetic:

"The cessation of activities of the alimentary canal (thus freeing energy for other parts); the shifting of the blood from less insistent abdominal viscera to the organs immediately essential to life itself, such as the lungs, the heart, the central nervous system, and, at critical moments, the skeletal muscles as well; the increased cardiac vigor; the quick abolition of the effects of muscular fatigue, the mobilizing of energy-giving sugar in the circulation—these are the changes which occur when fear or rage or pain causes the adrenal glands to pour forth an excessive secretion. These changes in the body are, each one of them, *directly serviceable in making the organism more efficient in the struggle which fear or rage or pain may involve*, for fear and rage are organic preparations for action, and pain is the most powerful known stimulus to supreme exertion. The organism which with the aid of increased adrenal secretion can best

muster its energies, can best call forth sugar to supply the laboring muscles, can best lessen fatigue, and can best send blood to the parts essential in the run or the fight for life, is most likely to survive. Such, according to the view here propounded, is the function of the adrenal medulla at times of great emergency."

The results of Cannon and Mendenhall (13, 14) are supplementary to the foregoing. They show that stimulation of the splanchnic nerves shortens the coagulation time of the blood, but this is not true if the adrenal gland is removed on the side stimulated. The same effect on coagulation is produced by artificial stimulation of sensory spinal nerves, and especially by emotional excitement. It follows that pain and excitement may be of service to an animal in preventing, through rapid clotting, the loss of blood from wounds received in a struggle.

Metzner (41) discusses the structure and functions of the autonomic system with special reference to the part played by emotions in determining its activity. His reference to a recent experiment by Elliott is of peculiar interest from a psychological point of view by reason of its bearing on the James-Lange theory of emotions. If the drug β-tetrahydronapthylamine hydrochloride is injected subcutaneously into a normal cat, the animal exhibits, as a result, all the signs of fear and rage. The same injection made in a cat which, by an operation, had had its spinal cord completely severed in the neck region produced a similar result. The cat became excited and enraged, even biting its keeper, although no nervous impulses could pass to the brain from the organs innervated by the sympathetic system.

The Gastric Hunger Mechanism.—A. J. Carlson and his associates have published in the last two years a series of papers on the physiology of the stomach which have contributed to the precision of our knowledge regarding the autonomic mechanisms involved in the sensation of hunger. The chief subject of these studies has been a young man (Mr. V.) with a complete closure of the œsophagus, and an abdominal fistula of the stomach through which he takes food—"a second Alexis St. Martin."

The sensation of hunger according to Carlson (17) is synchronous with strong contractions of the empty stomach, as recently demonstrated by Cannon and Washburn. Contractions of the œsophagus may also be involved (Carlson and Luckhardt, 26). Carlson has been able to arouse hunger sensations in his subject by mechanically produced contractions of the previously quiescent

stomach, and this he regards as "a demonstration of the peripheral genesis of hunger." He (**18**) finds that the contractions of the empty stomach may be inhibited (1) by stimulation of the gustatory end organs in the mouth, (2) by chewing indifferent substances, (3) by chewing palatable foods when hunger and appetite are present, and (4) by swallowing movements, the latter being, however, only partially effective. By these means the sensations of hunger are abolished to the same degree that the stomach contractions are inhibited. As to the nervous reflexes involved the author's opinion is that "the nerves of taste and at least some of those of general sense in the mouth contribute the afferent path. The actual inhibition is brought about either by a complete reflex through the inhibitory fibers in the splanchnic nerves and the vagi, or else the inhibition of the vagus tonus through action on the lower brain centers is the main factor." Carlson and Lewis (**25**) add smoking to the list of stimuli which, by a nervous reflex from the mouth, cause a cessation of hunger contractions in the empty stomach. The tightening of a belt around the abdomen, contrary to a popular belief, failed in large measure to produce the inhibitory effect except in the case of weak contractions.

In experiments on dogs Carlson (**21**) observed that "the sight and smell of food lead to temporary inhibition of the hunger contractions, and the inhibition is directly proportional to the degree of interest taken in the food." He regards this as a true "psychic" reflex. During sleep gastric hunger contractions persist with the same rate and intensity as when the dog is awake. Complete section of the splanchnic nerves increases the gastric tonus and the hunger contractions. Section of the vagi lowers the gastric tonus. When both splanchnics and vagi are cut the movements of the empty stomach continue, although a hypotonic condition exists. From this it seems clear to the author that "all the essential characteristics of the hunger contractions of the empty stomach are determined by the local gastric motor mechanisms." It is recognized that under certain conditions tonus fibers in the vagi may inaugurate or intensify the gastric hunger movements.

In both man and dogs reflexes inhibiting gastric hunger contractions can be obtained by introducing directly into the stomach weak acids and alkalis, alcoholic beverages, and even water (Carlson, **20, 22**). The inhibition is primarily a local reflex, as may be proved in dogs by sectioning the extrinsic nerves. The same inhibitory effect on the stomach is obtained by introducing similar

substances into the small intestine (Brunemeier and Carlson, 7); but in this reflex the extrinsic nerves play the principal rôle, although local reflex paths are to some extent involved.

The study of a variety of different influences on the gastric hunger mechanism leads Carlson (23) to the interesting conclusion that ordinary events of life tend to stimulate the inhibitory splanchnic apparatus, thus abolishing hunger. From such sources of stimuli the excitatory vagus apparatus appears to be singularly isolated. He regards this as a biological provision for limiting the positive stimulation of the hunger mechanism to influences developed by the state of nutrition, and to be looked for in the blood. Such stimuli are not afforded by fleeting changes in the nervous system. It is found, for example, that the hunger mechanism is inhibited by extreme muscular activity, such as occurs in running. The same effect follows strong stimulation of the cold and warm nerve endings in the skin. However, as might be expected from common experience, the after effect of prolonged stimulation by cold is a distinct increase in the gastric tonus and the hunger contractions. Intellectual processes and emotional states do not affect the vago-gastric tonus mechanism except so far as they cause inhibition via the splanchnic nerves. Sleep tends to have an opposite effect through the elimination of all inhibitory impulses.

During states of hunger occasioned by contractions of the empty stomach, Carlson (19) observed in his human subject vasomotor disturbances, acceleration of the heart beat, and an increased reflex excitability of the spinal cord, as evidenced by the knee jerk. Carlson and Braafladt (24) report that the normal gastric mucosa is devoid of pain and tactile sensibility, but that a low grade (protopathic) sensibility to extremes of temperature is present. Chemical (and probably mechanical) stimulation gives rise to a sensation identical with appetite. Such excitation of the gastric mucosa increases the reflex excitability of the spinal cord, and induces changes in vasomotor tonus. The latter appears dependent on conscious cerebral processes aroused by the gastric stimulation.

Miscellaneous.—Hoskins and Wheelon (35) criticize the "tonus theory" of adrenal secretion, which supposes that the adrenals constantly pour into the blood a substance that keeps the sympathetic system in a condition of partial contraction. In experiments on dogs they found that the sympathetic system, as evidenced by its continued vasomotor activity, does not suffer primarily from

adrenal extirpation. A study of the innervation of the cat's adrenal glands by the method of degeneration inclines Elliott (**32**) to the view that preganglionic fibers from the splanchnic nerves extend all the way to the adrenal medulla without the intervention of ganglion cells (postganglionic neurones). He could find no true ganglion cells in the medulla. The preganglionic fibers appeared to end in the nests of chromaffin cells.

Hoskins and Wheelon (**36**) obtained evidence that the destruction of the parathyroids in dogs is followed by a general increase of irritability in the sympathetic system. According to Rahe, Rogers, Fawcett, and Beebe (**44**), whatever part hormones may play in calling forth thyroid secretion, experiment shows that the gland responds to stimulation of the sympathetic nerves supplying it by discharging its physiologically active substances into the circulation.

Kuntz (**38**), after studying the histology of the enteric nervous system, is inclined to believe that the myenteric and submucous plexuses (plexuses of Auerbach and Meissner) contain complete sensory as well as complete motor neurones. According to this view there is present in the wall of the digestive tube a system of intrinsic reflex arcs with anatomically and functionally distinct afferent and efferent elements. Cannon and Burket (**10**) found that the nerve cells of the myenteric (Auerbach's) plexus preserve their functional activity for three hours after they have been deprived of their blood supply. When they succumb to the anemia the spontaneous contractions of the alimentary canal cease. This affords further evidence that these contractions are of nervous origin. Carpenter and Conel (**27**) were unable to secure morphological evidence of a differentiated sensory type of neurone in sympathetic ganglia (vertebral and prevertebral) of the cat and rabbit.

The familiar phenomenon of a quickened heart beat during voluntary exercise is believed by Gasser and Meek (**33**) to be due chiefly to the decrease in tone of the cardio-inhibitory center which influences the heart muscles through the vagus nerves. The accelerator nerves (sympathetic) appear to play a subsidiary rôle, and are probably called into action as a reinforcement only in times of great need. Their chief function seems to lie in maintaining the level of the resting pulse. It having recently been shown that the vagus nerves contain fibers which have a secretory influence on the kidneys, Pearce (**43**) undertook experiments on dogs to

determine if the increased secretion might be due to an augmented flow of blood through the renal vessels. His results indicate that this is not the correct explanation, since no evidence of vasodilation was forthcoming. The observations of Asher and Jost (2) are confirmatory. Von Anrep (1) found that the vagus of dogs sends both secretory and inhibitory fibers to the pancreas. Neuman (42) regards the afferent fibers of the abdominal vagus in the rabbit and cat as pressor components, *i. e.*, fibers causing vascular constriction through reflex stimulation of the vasoconstrictor center. The afferent fibers of the splanchnic nerves (sympathetic) are, on the other hand, regarded by Auer and Meltzer (3, 4) as depressor fibers, causing, reflexly, vascular dilation. Bruce (6) adduces evidence to show that under experimental conditions vasodilation may be effected by means of axone-reflexes. Such reflexes are confined to sensory fibers from the skin and their collaterals, and in the author's opinion point to the identity of vasodilator fibers with afferent dorsal root fibers.

According to Cavazzani (28) vasoconstrictor and vasodilator fibers pass from the cervical sympathetic to the blood vessels of the cerebral cortex, where in addition to a vasomotor function they have a certain tonic action concerning which no precise data are as yet available. Edwards (30) describes the anatomy and vasomotor phenomena of the sympathetic nervous system in the turtle. In a later paper (31) he reports experiments on the compensatory distribution of the blood during stimulation of vasomotor fibers in the splanchnic nerve of dogs. Cyriax and Cyriax (29) obtained contraction of the circular muscles at the junction of the descending colon and the rectum by stimulating the coccygeal ganglion of the sympathetic trunks.

The comprehensive summary of Huber (37) dealing with the morphology of the autonomic system brings together a variety of recent observations on its histological structure.

References

1. Anrep, G. von. The Influence of the Vagus on Pancreatic Secretion. *J. of Physiol.*, 1914, **49**, 1–8.
2. Asher, L. & Jost, W. Die sympathische Niereninnervation und deren Anpassungsfähigkeit an den Funktionzustand. *Zentbl. f. Physiol.*, 1914, **28**, 1–4.
3. Auer, J. & Meltzer, S. J. The Splanchnics as a Depressor Nerve. *Amer. J. of Physiol.*, 1913, **31**, xxi–xxii.
4. Auer, J. & Meltzer, S. J. Der afferente Splanchnikus als Depressor. *Zentbl. f. Physiol.*, 1913, **26**, 1316–1318.

5. Bergmann, G. v. Status des vegetativen Nervensystems. *Arch. f. Psych. u. Nervenkrankh.*, 1913, **51**, 1111–1113.
6. Bruce, A. N. Vaso-dilator Axon-reflexes. *Quar. J. of Exper. Physiol.*, 1913, **6**, 339.
7. Brunemeier, E. H. & Carlson, A. J. Reflexes from the Intestinal Mucosa to the Stomach. *Amer. J. of Physiol.*, 1914, **36**, 191–195.
8. Cannon, W. B. The Interrelations of Emotions as Suggested by Recent Physiological Researches. *Amer. J. of Psychol.*, 1914, **25**, 256–282.
9. Cannon, W. B. The Emergency Function of the Adrenal Medulla in Pain and the Major Emotions. *Amer. J. of Physiol.*, 1914, **33**, 356–372.
10. Cannon, W. B. & Burket, I. R. The Endurance of Anemia by Nerve Cells in the Myenteric Plexus. *Amer. J. of Physiol.*, 1913, **32**, 347–357.
11. Cannon, W. B. & de la Paz, D. Emotional Stimulation of Adrenal Secretion. *Amer. J. of Physiol.*, 1911, **28**, 64–70.
12. Cannon, W. B. & Hoskins, R. G. The Effects of Asphyxia, Hyperpnoea, and Sensory Stimulation on Adrenal Secretion. *Amer. J. of Physiol.*, 1911, **29**, 274–279.
13. Cannon, W. B. & Mendenhall, W. L. The Hastening of Coagulation by Stimulating the Splanchnic Nerves. *Amer. J. of Physiol.*, 1914, **34**, 243–250.
14. Cannon, W. B. & Mendenhall, W. L. The Hastening of Coagulation in Pain and Emotional Excitement. *Amer. J. of Physiol.*, 1914, **34**, 251–261.
15. Cannon, W. B., Shohl, A. T., & Wright, W. S. Emotional Glycosuria. *Amer. J. of Physiol.*, 1911, **29**, 280–287.
16. Carlson, A. J. The Character of the Movements of the Empty Stomach in Man. *Amer. J. of Physiol.*, 1912, **31**, 151–168.
17. Carlson, A. J. The Relation between the Contractions of the Empty Stomach and the Sensation of Hunger. *Amer. J. of Physiol.* 1913, **31**, 175–192.
18. Carlson, A. J. The Contractions of the Empty Stomach Inhibited Reflexly from the Mouth. *Amer. J. of Physiol.*, 1913, **31**, 212–222.
19. Carlson, A. J. The Influence of the Contractions of the Empty Stomach in Man on the Vasomotor Centre, on the Rate of the Heart Beat, and on the Reflex Excitability of the Spinal Cord. *Amer. J. of Physiol.*, 1913, **31**, 318–327.
20. Carlson, A. J. The Influence of Stimulation of the Gastric Mucosa on the Contractions of the Empty Stomach (Hunger Contractions) in Man. *Amer. J. of Physiol.*, 1913, **32**, 245–263.
21. Carlson, A. J. A Study of the Mechanisms of the Hunger Contractions of the Empty Stomach by Experiments on Dogs. *Amer. J. of Physiol.*, 1913, **32**, 368–388.
22. Carlson, A. J. The Inhibitory Reflexes from the Gastric Mucosa. *Amer. J. of Physiol.*, 1913, **32**, 389–397.
23. Carlson, A. J. The Nervous Control of the Gastric Hunger Mechanism (Man, Dog). *Amer. J. of Physiol.*, 1914, **34**, 155–171.
24. Carlson, A. J. & Braafladt, L. H. On the Sensibility of the Gastric Mucosa. *Amer. J. of Physiol.*, 1914, **36**, 153–170.
25. Carlson, A. J. & Lewis, J. H. The Influence of Smoking and of Pressure on the Abdomen (Constriction of the Belt) on the Gastric Hunger Contractions. *Amer. J. of Physiol.*, 1914, **34**, 149–154.
26. Carlson, A. J. & Luckhardt, A. B. The Condition of the Oesophagus during the Periods of Gastric Hunger Contractions. *Amer. J. of Physiol.*, 1914, **33**, 126–142.

27. Carpenter, F. W. & Conel, J. L. A Study of Ganglion Cells in the Sympathetic Nervous System, with Special Reference to Intrinsic Sensory Neurones. *J. of Comp. Neur.*, 1914, **24**, 269–279.

28. Cavazzani, E. Variations de l'excitabilité électrique de l'écorce cerebrale du lapin après la section du sympathique cervical. *Arch. ital. de Biol.*, 1913, **60**, 425–434.

29. Cyriax, E. F. & Cyriax, R. J. Mechanical Stimulation of the Coccygeal Ganglion. *Zsch. f. allg. Physiol.*, 1913, **14**, 297–308.

30. Edwards, D. J. A Study of the Anatomy and the Vasomotor Phenomena of the Sympathetic Nervous System in the Turtle. *Amer. J. of Physiol.*, 1914, **33**, 229–252.

31. Edwards, D. J. Compensatory Phenomena in the Distribution of the Blood during Stimulation of the Splanchnic Nerve. *Amer. J. of Physiol.*, 1914, **35**, 15–35.

32. Elliott, T. R. The Innervation of the Adrenal Glands. *J. of Physiol.*, 1913, **46**, 285–290.

33. Gasser, H. S. & Meek, W. J. A Study of the Mechanisms by which Muscular Exercise Produces Acceleration of the Heart. *Amer. J. of Physiol.*, 1914, **34**, 48–71.

34. Huebner, W. Zur Nomenklatur im vegetativen Nervensystem. *Zentbl. f. Physiol.*, 1913, **27**, 635–640.

35. Hoskins, R. G. & Wheelon, H. Adrenal Deficiency and the Sympathetic Nervous System. *Amer. J. of Physiol.*, 1914, **34**, 172–185.

36. Hoskins, R. G. & Wheelon, H. Parathyroid Deficiency and Sympathetic Irritability. *Amer. J. of Physiol.*, 1914, **34**, 263–270.

37. Huber, G. C. The Morphology of the Sympathetic System. *Folia neuro-biol.*, 1913, **7**, 616–639.

38. Kuntz, A. On the Innervation of the Digestive Tube. *J. of Comp. Neur.*, 1913, **23**, 173–192.

39. Langley, J. N. The Nomenclature of the Sympathetic and of the Related Systems of Nerves. *Zentbl. f. Physiol.*, 1913, **27**, 149–152.

40. Lewandowsky, —. Die neuere Entwicklung unserer Kenntnis vom sympathischen Nervensystem. *Berl. klin. Wochenschr.*, 1913, **50**, 231.

41. Metzner, R. Einiges vom Bau und von den Leistungen des sympathischen Nervensystems besonders in Beziehung auf seine emotionelle Erregung. *Samml. anat. und physiol. Vorträge und Aufsätze*, 1913, **2**, 305–333.

42. Neuman, K. O. The Afferent Fibres of the Abdominal Vagus in the Rabbit and Cat. *J. of Physiol.*, 1914, **49**, 34–37.

43. Pearce, R. G. Effect of Vagus Stimulation on the Blood Flow through the Kidney after Section of the Corresponding Splanchnic Nerve. *Amer. J. of Physiol.*, 1914, **35**, 151–161.

44. Rahe, J. M., Rogers, J., Fawcett, G. G. & Beebe, S. P. The Nerve Control of the Thyroid Gland. *Amer. J. of Physiol.*, 1914, **34**, 48–71.

45. Rogers, F. T. The Contractions of the Rabbit's Stomach during Hunger. *Amer. J. of Physiol.*, 1914, **36**, 183–190.

CEREBELLUM AND BRAIN-STEM[1]

BY ROSWELL P. ANGIER

Yale University

Rothmann (13), in extirpation experiments on the cerebellum of the monkey, reports that excision of the cortex of the lobus quadrangularis causes disturbance in the movements of the fore-leg of the same side and that similar disturbances of the corresponding hind-leg appear on cortical excision of the lobus semilunaris superior. Further, if the lateral, median, upper or lower portions, respectively, of either lobe are affected there occur well defined and constant disturbances in leg movement. By simultaneous extirpation of such various portions, either on the same or on opposite sides, different combinations of these defined disturbances may, therefore, be brought about. To such results Rothmann gives the Sherringtonian interpretation—that the cerebellum is the central organ of the proprioceptive system in control of the skeletal muscular reflex tonus and that, consequently, when cerebellar disturbances occur reactions dependent on this system fall out—when, for example, the lateral part of the cerebellar fore-leg center is extirpated, there occurs an absence of the proprioceptive antagonistic reflexes of the adductor muscles, so that the leg may be displaced outwards without being reflexly withdrawn. Rothmann also believes that he has demonstrated that the center for the innervation of the muscles of the larynx is likewise in the cerebellum (lobulus centralis of the lobus anterior). The outlook for extending to the cerebellum and the rest of the nervous system the postulate of that finer localization now become dominant for the cerebral cortex is, according to him, decidedly bright. Brouwer (1) finds that the cerebella of birds show (as Bolk and others had demonstrated for mammals) a certain fundamental type of fissure formation, but he feels that the bird-cerebellum hardly supports the conception of a typical localization of function of the kind maintained by Bolk for mammals. But from the study of bird-cerebella he is much inclined to look on the cerebellum as the regulative organ for the proper coördination of a part of bilaterally functioning muscle-groups. Camis (4) studied the effects of injections of nicotine into the nuclei of the cerebellum. Ocular disturbances predominated when the injections occurred in a lateral lobe and general motor dis-

[1] For the last previous review on this topic see the BULLETIN, 1913, 10, 138–142.

turbances when in the vermis. The broad conclusion is that nicotine acts as a depressor of cerebellar function and not as an excitor —the phenomena being similar to those following excision of the labyrinth. The facts are in line, so the author feels, with his theory that the grey nuclei of the cerebellum represent the center for the cephalic autonomic system, of which the vestibular nerve is one of the most important afferent paths.

Brown (2) noticed, in stimulation experiments on the motor cortex of monkeys, periods of inexcitability accompanied by strong postural flexion of certain muscles of the limbs. Various considerations prompted him to seek the centers for this postural activity in the mid-brain. Stimulation of a point at the cross section of the posterior longitudinal bundle on the exposed surface of the mid-brain of the decerebrate animal at the level of the superior colliculi brought about postural contraction of the flexors of the ipsilateral arm characterized by marked and prolonged after-discharge. Stimulation of the contralateral area evoked similar postural contraction of the extensors, and various typical effects of synchronous compounding of these two phases of stimulation are also described. Furthermore, the action of the *non-postural* contractions (*i. e.*, absence of after-discharge) of flexors evoked by stimulation of the appropriate cortico-spinal tract is antagonistic to the after-discharge in these flexors due to the described mid-brain stimulation. "The non-postural cerebral activity serves to abolish the postural mid-brain activity and thus to leave, perhaps, a virgin field for any subsequent reaction." The paper is too detailed for adequate review; among many significant facts the specific conclusion emerges that it is doubtless the activity of the posterior longitudinal bundle that introduces the postural reactions noticed during the periods of inexcitability in the experiments on cortical stimulation. Forbes and Sherrington (9) report that certain acoustic stimuli evoked reflex movements in the cat from which the brain had been removed, leaving attached to the cord only the cerebellum, the bulb, the posterior and, usually, some part of the anterior, colliculi. Some of the reflexes were such as normally to orient the animal to the stimuli, while others were mimetic responses expressive of anger and aggression. Magnus (10) seeks to determine which parts of the central nervous system must be intact in order that the tonic reflexes, originating in neck and labyrinth, of the bodily musculature (neck and limb movements) may occur. Two groups of such reflexes are distinguished: (1) those released through chang-

ing the position of the head in space—taking their origin, therefore, in the labyrinth; (2) those brought about through changing the position of the head in relation to the trunk, originating in the muscles, etc., of the neck and carried to the central nervous system chiefly through the three uppermost cervical posterior roots. By successive excisions of parts of the brain it was found that the first type of reflexes disappears only when the section of the brain-stem was made just behind the entrance of the eighth nerve—cerebellum and all the rest of the brain having been cut away. All reflexes of the second type remained down to a section ½ mm. anterior to the origin of the second cervical nerve. The respective centers are, therefore, not further anterior than the points of entrance of the afferent paths necessary for the release of the reflexes. The whole medulla may thus go so far as the neck reflexes are concerned. Weed (**14**), experimenting on fifty cats, locates the center for decerebrate rigidity in the mid-brain and, probably, in the nucleus ruber. Magnus, however, in an appendix to the article just outlined, maintains that all the parts deemed by Weed to be essential may be cut away without abolishing decerebrate rigidity—agreeing, therefore, with Sherrington. Barenne (**5**), noticing that the decerebrate rigidity of the cat did not lessen when the autonomic nerve supply was severed, concludes that the phenomenon is not simply an accentuation of the autonomic tonic innervation of the muscles, but that the efferent impulses arousing and maintaining the rigidity are those of the anterior root fibers of the cerebro-spinal tracts.

Martin and Gruber (**11**) attempt to determine the nervous mechanism concerned in the effects of muscular exercise on heart-rate, arterial pressure and changes in respiration. They believe, as the result of several types of experiment, that the immediate effect of muscular exercise on the bulbar centers is due chiefly to associative innervation from the motor cortex, depressing the cardio-inhibitory center, the vasoconstrictor center and the respiratory center, and not to reflexes from the organs of the kinæsthetic senses. Brown (**2**) refers to a respiratory tract in the mid-brain, determined by evoking gasping movements by faradic stimulation of the monkey's brain on a cross section through the anterior part of the anterior colliculi. The center is very focally localizable about 3 mm. from the aqueduct. Foà (**7, 8**) brings further evidence to show that the bulbar vaso-motor center may function independently of the respiratory center and that both are automatic,

i. e., dependent on metabolic rather than on sensory stimulation via afferent nerves. The so-called respiratory rhythm of the hæmodynamic curve of the dog may persist, for instance, when means are taken to put the respiratory center out of function. Feiling (6), examining bulbar lesions in the brain of a man who had had a fracture of the base of the skull, found degenerations similar to those in dogs that had led to a bulbar localization of a salivary center. The observations suggest, but, in the absence of confirmatory clinical evidence, do not prove, the existence of a similar center in man. Pfeifer (12) offers a review of the technique of physiological investigations of the brain, particularly of its deeper lying parts, without removal of the cerebrum.

References

1. Brouwer, B. Ueber das Kleinhirn der Vögel nebst Bemerkungen über das Lokalisationsproblem im Kleinhirn. *Folia neuro-biol.*, 1913, **7**, 349–377.
2. Brown, T. G. On Postural and Non-postural Activities of the Mid-brain. *Proc. Roy. Soc.*, 1913, *B* **87**, 145–162.
3. Brown, T. G. A Respiratory Tract in the Mid-brain. *J. of Physiol.*, 1914, **48**, xxxii.
4. Camis, M. Contributi alla Fisiologia del Labirinto (viii, Intorno agli effetti delle iniezioni di nicotina nel cervelletto). *Folia neuro-biol.*, 1913, **7**, Erg. Bd., 157–174.
5. Dusser de Barenne, J. G. Ueber die Enthirnungsstarre (Decerebrate rigidity Sherrington's) in ihrer Beziehung zur efferenten Innervation der quergestreiften Muskulatur. *Folia neuro-biol.*, 1913, **7**, 651–654.
6. Feiling, A. On the Bulbar Nucleii, with Special Reference to the Existence of a Salivary Center in Man. *Brain*, 1913, **36**, 255–265.
7. Foà, C. Periodische Automatie des herzhemmenden und des vasomotorischen Bulbärzentrums. Pflüger's *Arch. f. d. ges. Physiol.*, 1913, **153**, 513–545.
8. Foà, C. Weitere Untersuchungen über periodische Automatie des herzhemmenden und des vasomotorischen Bulbärzentrums. Pflüger's *Arch. f. d. ges. Physiol.*, 1914, **157**, 561–570.
9. Forbes, A. & Sherrington, C. S. Acoustic Reflexes in the Decerebrate Cat. *Amer. J. of Physiol.*, 1914, **35**, 367–375.
10. Magnus, R. Welche Teile des Zentralnervensystems müssen für das Zustandekommen der tonischen Hals- und Labyrinthreflexe auf die Körpermuskulatur vorhanden sein. Pflüger's *Arch. f. d. ges. Physiol.*, 1914, **159**, 224–250.
11. Martin, E. G. & Grubner, C. M. On the Influence of Muscular Exercise on Activity of Bulbar Centers. *Amer. J. of Physiol.*, 1913, **32**, 315–328.
12. Pfeifer, B. Zur Technik der experimentellen Untersuchungen am Gehirn, insbesondere am Sehhügel. *Arch. f. Psychiat. u. Nervenkr.*, 1914, **54**, 107–120.
13. Rothmann, M. Zur Kleinhirnlokalisation. *Berl. klin. Wock.*, 1913, **50**, 336–339.
14. Weed, L. H. Observations upon Decerebrate Rigidity. *J. of Physiol.*, 1914, **48**, 205–227.

RESPIRATORY, CIRCULATORY AND PSYCHOGALVANIC PHENOMENA[1]

BY ARTHUR H. SUTHERLAND

Yale University

A large literature of physiological chemistry now confronts the searcher for information as to automatisms of the above types. Chemical stimuli, electrolytic dissociation products and the chemical analysis of excretory products replace the former discussions of automatisms. The automatisms have become reflexes. Hooker (26), using excised turtle muscle from the arterial and venous walls, finds this muscle more speedily influenced by carbon dioxide than is the case with similar muscle from warm-blooded animals. In small amounts, carbon dioxide relaxes vascular muscle, and if the muscle is in rhythmic movement when stimulated, the rhythmicity is abolished or depressed. Oxygen is essential to rhythmicity and the maintenance of tonus. Douglas and Haldane (10) find that during the hyperpnœa of muscular work there is a very great increase in the volume of the effective dead space; and this increase is due to a dilatation of the bronchi with a consequent diminished resistance to the passage of air. This offers a possible explanation, according to Cook and Pembrey (5), for what is commonly known as "second wind." This may now be thought of as an adjustment of the respiratory and circulatory systems brought about chiefly by carbon dioxide, at the demand of the muscles for an adequate supply of blood. Hasselbalch (22) who claimed to have discovered in H ion concentration of arterial blood the main factor in the regulation of breathing, is vigorously disputed by Higgins (23), who finds that food, posture and other factors influence the tension of carbon dioxide in the alveoli, and that these variations, especially that of change of posture, do not appear to be due to H ion concentration, but apparently to some other agent. In high altitudes, Fitzgerald (14) has compared the alveolar tension with that at sea level, and lays down the following law, which will be of interest to those interested in the relation of conduct to the weather. "The lowering of carbon dioxide pressure is in direct proportion to the diminution of barometric pressure, and amounts to 4.2 mm. or 10.5 per cent. of the sea-level value for each 100 mm. of diminution of barometric pressure." An interesting sex difference occurs

[1] For the last previous review on this topic see the BULLETIN, 1913, 10, 142–146.

in respect to this alveolar pressure. Both in high altitudes and at sea level, the pressure for woman is approximately 3 mm. lower than that for man. And for every 100 mm. fall of atmospheric pressure, the percentage of hæmoglobin is increased about 10 per cent. for men. For women the values are about 11 per cent. lower than for men, but greater irregularity is observed. How Hasselbalch's chemical explanation would apply to the results of Meyer (37) it is difficult to see. Meyer produced pain by a clamp on the fingernail of the little finger and obtained a hyperpnœa. Carbon dioxide expulsion is diminished and the respiratory quotient increased. Ether also produces hyperpnœa in one minute when applied in low concentration; in high concentration, the breathing is diminished. Individuals were found to differ however. On the other hand, apnœa is produced in the duck by submersion in water, or by drawing the head into that position which would be assumed in diving. Breathing continues when the vertex of the head is upward; it ceases when the vertex faces downward. Huxley (27, 28, 29) concludes that the duck resists asphyxia, partly by this reflex cessation in breathing, and partly by a consequent reflex retardation of heart action by means of which less oxygen is demanded. Paton (38) shows that this respiratory rhythm is capable of variations, and that ducks show individual differences which may be grouped into three types, (1) those easily elicited by posture; (2) those in which the labyrinths are the effective mechanism; (3) those in which the cervical relations are more important. Blumenfeldt and Putzig (3) agree with Foà (15) in believing that the frequency changes correlate with a primary autochthonous activity of the inhibitory center, which is secondarily regulated through peripheral stimuli; while Christiansen and Haldane (4) find that true apnœa is a chemical apnœa and conclude "there is now left no evidence, so far as the authors know, in support of the vagus theory of inhibition of respiration." The pathway of the reflex is discussed by Barry (2) who finds that inspiratory impulses pass to the medulla by way of somatic nerves to the cord. Visceral impulses may be present and pass upward via the stellate ganglion. Afferent impressions of visceral origin conveyed by the vagus are chiefly inhibitory.

Methodological studies with the galvanometer continue and among these Erlanger and Garrey (12) review the literature both physical and physiological with particular reference to applications in the laboratory. Einthoven (11), Samojloff (46) and

Cybulski (6) in mutual admiration attribute differences of results to differences of methodology; and Galler (16) has devised a method of measuring the simultaneous effects of direct versus indirect stimulations which make possible a measurement of polarization during stimulation. Gildermeister (19) however criticizes this work. The clinical possibilities of the use of the galvanometer are discussed by Kraus, Nicolai and Meyer (31), while Martin, Porter and Nice (34) show the differences which result from various electrodes and compare the results from muscle, nerve and skin of lower animals with the results from the skin of man. Grabfield and Martin (20) demonstrate that the sensory threshold for faradic stimulation shows a diurnal rhythm which reaches a point of highest irritability at 10 to 11 A.M., declines to 4:30 P.M., then rises. Martin, Bigelow and Wilbur (33) show that during the night there are two peaks of low irritability, one occurring about midnight, the other about four hours later, and suggest that these variations may correspond to variations in the depth of sleep, and may be expressions of a deep-seated rhythm of the nervous system more or less independent of the waking and sleeping state. Martin, Withington and Putnam (35) show that from Monday to Saturday there is an almost continuous fall in irritability, when the subjects pursued the same routine for several weeks. This is interpreted as a result of general fatigue. The curve rises to its high point on Monday morning. But while Grabfeld and Martin (20) show that the diurnal rhythm for faradic stimulation corresponds in general to that for reaction times and the ergographic results and suggest its practicability for studies of abnormal individuals, Dittler and Günther (9) find no curve typical for any particular variety of mental and nervous disease. Pieron (45) finds evidence which he believes differentiates two types of galvanic phenomena; one of muscular origin, an electromotive force; and the other a lowering of cutaneous resistance under the influence of emotions, which facts suggest again the differences pointed out by Martin, Porter and Nice (34)—that with needle or wire electrodes the cutaneous receptors may be affected, while with liquid electrodes the receptors to respond may be those of deep sensibility.

Concerning circulatory phenomena, Martin and Lacey (36) find that a stimulus sufficient to produce a spinal reflex of skeletal muscle is accompanied by a reflex drop in blood pressure, and suggest that even when fear, anger, and other emotional states of a pressor inciting character are not aroused, this fall in blood pres-

sure is due to a reflex peripheral vasodilation. Stewart (47) reports that when the temperature of the environment of the heart is raised, a stimulus previously sufficient to inhibit the rhythmic pulse no longer has that effect. Hasegawa (21), working with excised frog's heart, was able to secure normal rhythmic pulsations with a combination of blood serum, NaCl 0.6 per cent. + CaCl 0.026 per cent. + KCl 0.03 per cent., but Peterson and Gasser (38) believe that metabolic products formed in active muscles play no part in the increase of heart rate resulting from muscular activity, insofar as this action is upon the heart muscle directly or upon the cardiac endings of extrinsic nerves. Gesell correlates (18) excretion of urine chlorides, urea and nitrogen with arterial pulse, and Hill, McQueen and Ingram (24) show that the pulse wave is assisted to the periphery of the body by elastic resonance of the tissue. The vigor of the circulation depends on the tone of the tissues, the tautness of skin and muscles and, particularly, of the abdominal wall. Hill, McQueen and Flack (25) compare the difference of readings of the manometer on arm and leg, the obliteration of pulse being taken as a measure of the systolic pressure. They find the radial reading is a satisfactory indication of blood pressure, and that lower pressure in the leg is due to the larger lumen, greater resonance of tissues and lability of walls of its bloodvessels. Moutier (48) also briefly emphasizes the relation of peripheral blood pressure to tension of the abdominal wall.

Kent (30) offers a most interesting contribution to a possible explanation of the continuity of cardiac automatism in the discovery that the bundles of connective tissue between auricles and ventricles, if followed up, are found to be directly connected with muscle tissue and with the nervous structures of the auriculo-ventricular groove. They have many points in common with the neuromuscular spindles of skeletal muscle, and the function suggested is that of coördination of heart chambers.

Several mere abstracts of investigations on certain ocular-cardiac and respiratory reflexes, aroused by pressure on the eye-ball, hardly call for detailed comment, since no data that would warrant the conclusions are given (1, 7, 8, 13, 17, 32, 40 to 44).

References

1. Aviragnet, E. C., Dorlencourt, H., & Bouttier, H. Le réflexe oculo-cardiaque au cours de l'intoxication diphtérique. *C. r. soc. d. biol.*, 1914, 77, 771.
2. Barry, D. T. Afferent Impressions from the Respiratory Mechanism. *J. of Physiol.*, 1913, 45, 473–481.

3. Blumenfeldt, E. & Putzig, H. Experimentelle elektrokardiographische Studien über die Wirkung der Respiration auf die Herztätigkeit. Pflüger's *Arch. f. d. ges. Physiol.*, 1914, **155**, 443–460.
4. Christiansen, J. & Haldane, J. S. The Influence of the Distension of the Lungs on Human Respiration. *J. of Physiol.*, 1914, **48**, 272–277.
5. Cook, F. & Pembrey, M. S. Observations on the Effect of Muscular Exercise upon Man. *J. of Physiol.*, 1913, **45**, 429–446.
6. Cybulski, N. Elektrische Ströme in tätigen Muskeln, deren Character und Eigenschaften. *Bull. d. l'akademie des sci. de cracovie*, Serie B, 1912, 469.
7. Delava, P. Etude expérimentale des modifications circulatoires et respiratoires lors de la compression oculaire. *C. r. soc. d. biol.*, 1914, **77**, 555–556.
8. Delava, P. Etude expérimentale des effets de la compression oculaire apres l'administration de morphine, de chloroform, d'atropine, de pilocarpine et d'adrénaline. *C. r. soc. d. biol.*, 1914, **77**, 631–632.
9. Dittler, R. & Günther, H. Über die Aktionsströme menschlicher Muskeln bei natürlicher Innervation nach Untersuchungen an gesunden und kranken Menschen. Pflüger's *Arch. f. d. ges. Physiol.*, 1914, **155**, 251–274.
10. Douglas, C. G. & Haldane, J. S. The Capacity of the Air Passages under varying Physiological Conditions. *J. of Physiol.*, 1913, **45**, 235–238.
11. Einthoven, W. Über die Deutung des Elektrokardiogramms. Pflüger's *Arch. f. d. ges. Physiol.*, 1912, **149**, 65–86.
12. Erlanger, J. & Garrey, W. E. Faradic Stimuli; A Physical and Physiological Study. *Amer. J. of Physiol.*, 1914, **35**, 377–473.
13. Fabre, —. & Petzetakis, —. Persistance du réflexe oculo-cardiaque pendant l'anesthésie générale. *C. r. soc. d. biol.*, 1914, **76**, 343–344.
14. Fitzgerald, M. P. Further Observations on the Changes in Breathing and the Blood at various High Altitudes. *Proc. Roy. Soc.*, 1914, *B* **88**, 248–257.
15. Foà, C. Periodische Automatie des herzhemmenden und des vasomotorischen Bulbärzentrums. Pflüger's *Arch. f. d. ges. Physiol.*, 1913, **153**, 513–545.
16. Galler, H. Über den elektrischen Leitungswiderstand des tierischen Körpers. Pflüger's *Arch. f. d. ges. Physiol.*, 1912, **149**, 156–174.
17. Garnier, M. & Lévi-Franckel, G. Le réflexe oculo-cardiaque dans la grossesse. *C. r. soc. d. biol.*, 1914, **77**, 645–646.
18. Gesell, R. A. The Relation of Pulse Pressure to Renal Secretion. *Amer. J. of Physiol.*, 1913, **32**, 70–93.
19. Gildermeister, M. Über die im tierischen Körper bei elektrischer Durchströmung entstehender Gegenkrafte. Pflüger's *Arch. f. d. ges. Physiol.*, 1913, **149**, 389–
20. Grabfield, G. P. & Martin, E. G. Variations in the Sensory Threshold for Faradic Stimulation in Normal Human Subjects. I. The Diurnal Rhythm. *Amer. J. of Physiol.*, 1913, **31**, 300–308.
21. Hasegawa, Dr. Die natürlichen Herzreize. *Arch. f. Anat. u. Physiol.* (*Physiol. Abt.*), 1914, **14**, 273–289.
22. Hasselbalch, K. A. Neutralitätsregulation und Reizbarkeit des Atemzentrums in ihren Wirkungen auf die Kohlensäurespannung des Blutes. *Biochem. Zsch.*, 1912, **46**, 403–439.
23. Higgins, H. L. Influence of Food, Posture and other Factors on the Alveolar Carbon Dioxide Tension in Man. *Amer. J. of Physiol.*, 1914, **34**, 114–126.
24. Hill, L., McQueen, J. & Ingram, W. W. The Resonance of Tissues as a Factor

in the Transmission of the Pulse and in Blood Pressure. *Proc. Roy. Soc.*, 1914, B 87, 255–268.

25. Hill, L., McQueen, J. & Flack, M. Conduction of the Pulse Wave and the Measurement of Arterial Pressure. *Proc. Roy. Soc.*, 1914, B 87, 344–353.
26. Hooker, D. R. The Effect of Carbon Dioxide and of Oxygen upon the Muscular Tone in the Blood Vessels and Alimentary Canal. *Amer. J. of Physiol.*, 1912, 31, 47–58.
27. Huxley, F. M. On the Reflex Nature of Apnoea in the Duck. I. The Reflex Nature of Submersion Apnoea. *Quart. J. of Exper. Physiol.*, 1913, 6, 147–157.
28. Huxley, F. M. On the Reflex Nature of Apnoea in the Duck. II. Reflex Postural Apnoea. *Quart. J. of Exper. Physiol.*, 1913, 6, 159–182.
29. Huxley, F. M. On the Resistance to Asphyxia of the Duck in Diving. *Quart. J. of Exper. Physiol.*, 1913, 6, 183–196.
30. Kent, A. F. S. Neuromuscular Structures in the Heart. *Proc. Roy. Soc.*, 1914, B 87, 198–203.
31. Kraus, F., Nicolai, G. F., und Meyer, F. Prinzipielles und Experimentelles über das Elektrokardiogramm. Pflüger's *Arch. f. d. ges. Physiol.*, 1913, 155, 97–167.
32. Loeper, M. & Mougeot, A. Le réflexe oculo-cardiaque dans le diagnóstique de la nature des bradycardies. *C. r. soc. d. biol.*, 1914, 76, 104–105.
33. Martin, E. G., Bigelow, G. H. & Wilbur, G. B. Variations in the Sensory Threshold for Faradic Stimulation in Normal Human Subjects. II. Nocturnal Variation. *Amer. J. of Physiol.*, 1913, 33.
34. Martin, E. G., Porter, E. L. & Nice, L. B. The Sensory Threshold for Faradic Stimulation in Man. *Psychol. Rev.*, 1913, 20, 194–205.
35. Martin, E. G., Withington, P. R. & Putnam, J. J., Jr. Variations in the Sensory Threshold for Faradic Stimulation in Normal Human Subjects. III. The Influence of General Fatigue. *Amer. J. of Physiol.*, 1914, 34, 97–105.
36. Martin, E. G. & Lacey, W. H. Vasomotor Reflexes from Threshold Stimulation. *Amer. J. of Physiol.*, 1914, 33, 212–228.
37. Meyer, A. L. Hypernoea as a Result of Pain and Ether in Man. *J. of Physiol.*, 1914, 48, 47–52.
38. Paton, D. N. The Relative Influence of the Labyrinthine and Cervical Elements in the Production of Postural Apnoea in the Duck. *Quart. J. of Exper. Physiol.*, 1914, 33, 197–207.
39. Peterson, M. S. & Gasser, H. S. The Effect of Chemical Products of Muscular Activity on the Frequency and Force of the Heart Beat. *Amer. J. of Physiol.*, 1914, 33, 301–312.
40. Petzetakis, M. De l'existence d'un réflexe oculo-respiratoire et oculo-vasomoteur a l'état normal. *C. r. soc. d. biol.*, 1914, 77, 218–220.
41. Petzetakis, M. Phénomènes circulatoires et respiratoires, produits par la compression oculaire. *C. r. soc. d. biol.*, 1914, 76, 366–369.
42. Petzetakis, M. Abolition du réflexe oculo-cardiaque par l'atropine; son exagération par la pilocarpine; sa persistance pendant l'epreuve du nitrite amyle. *C. r. soc. d. biol.*, 1914, 76, 247–249.
43. Petzetakis, M. Réflexe oculo-cardiaque et dissociation auriculo-ventriculaire. *C. r. soc. d. biol.*, 1914, 76, 409–412.
44. Petzetakis, M. Etude expérimentale sur les voies centrifuges du réflexe oculo-cardiaque. *C. r. soc. d. biol.*, 1914, 76, 657–658.

45. Pieron, H. Sur les variations de la résistance du corps d'origine affective. *C. r. soc. d. biol.*, 1914, **77**, 332.
46. Samojloff, A. Über einige Punkte der Saitengalvanometerie. Pflüger's *Arch. f. d. ges. Physiol.*, 1913, **149**, 483–496.
47. Stewart, G. N. Einfluss der Herztemperatur auf die Tätigkeit der Hemmungsnerven des Herzens. *Zsch. f. Biol.*, 1912, **59**, 531–560.
48. Moutier, A. Interdépendance de l'hypotension artérielle périphérique et de l'hypertension artérielle abdominale. *C. r. acad. d. sc.*, 1914, **158**, 1440.

THE NEURONE[1]

BY H. B. FERRIS

Yale University School of Medicine

The work of the past two years on the morphology of the neurone has been largely devoted to the determination of the identity of the various morphological entities hitherto described in the cell-body (*perikaryoplasm*) and the relationship existing between them. A new method of studying the nerve cell, known as vital staining, has also been devised. It will be convenient to consider in turn, the bearing of the literature on our knowledge of the four described morphological differentiations of the neuronal perikaryoplasm, viz., Nissl's granules, neurofibrils, the canalicular apparatus (Binnennetz) and mitochondria.

1. *Nissl's Granules.*—Van Herwerden (**16**) has shown that under the influence of nuclease from the spleen of cattle, these granules lose their staining quality while other basophilic cell-granules are not affected. He draws the conclusion therefore, that Nissl's granules are not made of albumases, but of a nucleic acid combination. Marinesco (**10**) has studied the fresh nerve cell in the serum of the animal from which it comes, by means of the ultramicroscope. He finds in the cytoplasm of cells from the peripheral ganglia and the central nervous system of mammals, birds and amphibians a varying number of colloidal granules, of varying size and density depending upon the animal and the size of the cell. These granules have a form similar to that of Nissl's bodies; they are found also in the dendrites, but not in the axis cylinders. Marinesco believes that these are Nissl's granules and that this proves that these granules are not precipitation products but exist in the living cell. Held (**5**) studied nerve cells by "vital fixation." He decapitated dogs and immediately removed pieces of the spinal cord and made

[1] For last previous review of this topic, consult the Bulletin, 1913, **10**, 153–163.

smears on glass slides. In twenty-five seconds these were fixed in alcohol kept at a temperature below 0° C., as sudden freezing is believed to prevent cytological changes by alcohol. In the frozen sections Held was able to make out both Nissl's granules and neurofibrils, in a somewhat modified condition however, due to the freezing. The network-like appearance of the granules he believed corresponds to the "glia network" described by Möllgaard. Held considers that this experiment proves the existence of Nissl's granules and neurofibrils in the living nerve cell. Malone (8) claims that Nissl's bodies are characteristically different in the various neurones, so that it is possible to differentiate a motor from a sensory and even a somatic efferent from a splanchnic efferent. If this claim of Malone prove to be true, it will be an important aid in determining the still uncertain functions of the various cell groups.

2. *Neurofibrils.*—Von Szüto (15) takes the position that the neurofibrils are a supporting mechanism rather than a conducting one. He bases this conclusion on the fact that he finds the arrangement of the neurofibrils varied according to the form of the cell and that they therefore form a supporting framework. His paper is not at all convincing. As stated above, Held by means of "vital fixation" and Marinesco as a result of his study of the fresh nerve cell in serum by the ultramicroscope, conclude that the neurofibrils are not precipitations due to the fixing agents, but represent real entities of the living cells. Cowdry (3) has recently studied the development of the neurofibrils in the nerve cells of the chick. He finds that their formation begins in the fifteen somite stage, corresponding to forty hours of incubation. Their formation however, does not begin simultaneously in all parts of the nervous system, but they appear earliest in the hind-brain in the region of the otic invagination, in the mid-brain and the nuclei and root fibers of the cranial nerves, and not till later in the fore-brain. It is not till much later that their differentiation occurs in the spinal ganglion cells.

The functional significance of this variation in the time of neurofibrillar differentiation is not clear. While the neurofibrils are most numerous in neuroblasts, they are also found in apolar and bipolar cells. The first differentiation begins in the region of the nucleus in the form of a network, whether by extrusion of nuclear material, or only under the influence of the nucleus, is not known. It is still the general belief that the neurofibrils from the conducting mechanism.

3. *The Canalicular Apparatus.*—It has been proved by the observations of many investigators that this apparatus is not, like the neurofibrils and Nissl's granules, peculiar to the neurone, but is found in many different cells of the body, not only of vertebrates but of invertebrates as well. According to Cowdry (3) the canalicular apparatus has been demonstrated in the embryo chick as early as the forty-fourth hour of incubation, and is found at first only at one pole of the nucleus, later extending around the nucleus. Regressive changes and fragmentation of this apparatus have been described in certain toxic and pathologic conditions. Also the division of this apparatus during mitosis of non-nervous cells and its distribution to the daughter cells has been described. While there is still some difference of opinion as to the identity of this apparatus and the Golgi net, the predominating opinion is that they are the same. Recent investigations have thrown no further light on the possible functions of this canalicular system.

4. *Mitochondria.*—Mitochondria are not confined to nerve cells, but are found, like the canalicular apparatus, in cells in general. Busacca (2) describes the mitochondria in adult reptilian nerve cells as entirely separate from both Nissl's bodies and neurofibrils and independent of them, but concentrated around the nucleus or in scattered groups through the cytoplasm. They are found in both dendrites and axones. Bialkowska and Kulikowska (1) have demonstrated that the same is true in the nerve cells of insects. Luna (7) has found mitochondria in the nerve cells of adult amphibians as well as mammals. Cowdry (3) has tried to solve the question as to whether any genetic relationship exists between the mitochondria and neurofibrils, as is believed by Meves, Duesberg, Hoven and others. His observations included not only a study of fixed and stained tissue, but also of the living nerve cells of the chick, with and without vital stains. He finds that mitochondria exist very early in the nerve cells of the chick, before any somites are formed. They appear as more rounded granules in spheroidal cells and longer and straighter filaments in elongated cells and never form a network. He denies that the neurofibrils are derived from the mitochondria for the following reasons: (1) no changes occur in the mitochondria coincident with the development of the neurofibrils; (2) no decrease is seen in the mitochondria as the neurofibrils increase; (3) no morphological transitions exist between the mitochondria and the neurofibrils. He concludes that mitochondria may be regarded as a more generalized element of the cell having a

less specific function than the neurofibrils. What this function may be is not known.

Vital Staining of the Neurone.—There are a number of investigators working with vital stains in an attempt to determine the morphological differentiations existing in the living nerve cell. Rachmanow (13) has studied the effect of isamin blue and trypan blue on the central nervous system. The dilute stain is given by hypodermatic, intraperitoneal or intravenous injection. He finds that while certain cells of mesodermal origin stain, the neurones and glia cells do not, with the exception of certain cells of the tuber cinereum and the hypophysis. After traumatic injury of the central nervous system however, some of the injured neurones may stain. This latter fact has also been confirmed by MacCurdy and Evans (9). Doinikow (4), studying the effect of vital stains on the peripheral nervous system, found that while cells of the connective tissue coats of a nerve stained, the cells of Schwann stain only slightly at one or more poles of the nucleus. Although the living neurones of the central nervous system do not stain with vital dyes, those of the peripheral ganglia do, showing fine granules which are probably mitochondria. The introduction of these methods of vital staining opens many new fields for investigation and holds out new hopes for the future, but up to the present time they have added but little to our knowledge of the neurone.

Little attention has been given to the question of interneuronal relationship. Monti (11), however, has studied this matter in insects and claims that there the neurone is not a discrete entity, but that an anastomosis of the processes exists and that the neurofibrils pass from one cell to another—that, therefore, the nerve cells in insects constitute a true syncytium. This finding does not, however, negative the neurone theory provided each neurone is developed from a single neuroblast, which so far as is known is true in insects. Still further evidence in favor of the outgrowth theory is furnished by the work of Ingebrigtsen (6), who observed that axones grew out of pieces of the cerebella of young cats and guinea-pigs when grown in plasma, but contrary to the observations of some investigators no anastomoses were seen. The axones grew out into the plasma entirely isolated and without support. This would seem to nullify the doctrine of stereotropism as stated by Harrison, so far at least as the outgrowth of the axone is concerned. Müller (12), studying nerve development in Selachians, also concludes that the axones are outgrowths, from the fact that the peripheral ends of the developing axones are free and not at

first connected with the myotomes, but secondarily make such connection. Zander (17) calls attention to the fact that nerve fibres are found crossing the median line of the body where a fissure existed in the embryo which was obliterated later by the fusion of the adjacent walls, as for example, the median line of the ventral abdominal wall. This he interprets as indicating that the fibres must have grown across, a fact in favor of the outgrowth theory.

References

1. Bialkowska, W. & Kulikowska, Z. Ueber den feineren Bau der Nervenzellen bei verschiedenen Insekten. *Bull. de l'Acad. d. Sc. de Cravovie*, 1912 (Review in *Folia neuro-biol.*, 1913, 7, No. 6).
2. Busacca, A. L'apparato mitocondriale nelle cellule nervose adulte. *Anat. Anzeiger*, Bd. 47, N. 24.
3. Cowdry, E. V. The Development of the Cytoplasmic constituents of the Nerve Cells of the Chick. 1. Mitochondria and Neurofibrils. *Amer. J. of Anat.*, 1914, 15, No. 4.
4. Doinikow, B. Histologische und histopathologische Untersuchungen am peripheren Nervensystem mittels vitaler Färbung. *Folia neuro-biol.*, 7, 731–749.
5. Held, T. J. Möllgaard's Reticulum. *J. of Comp. Neur.*, 1913, 23, 315–349.
6. Ingebrigsten, R. Regeneration von Achsenzylindern *in vitro*. *Münch. med. Woch.*, 1913, No. 41, 2265.
7. Luna, E. I condriosomi nelle cellule nervose adulte. *Folia neurobiol.*, 1913, 7, 505–511.
8. Malone, E. F. Recognition of Members of the Somatic Motor chain of Nerve Cells by Means of a Fundamental Type of Cell Structure, and the Distribution of such Cells in certain Regions of the Mammalian Brain. *Anat. Record*, 1913, 7, No. 3.
9. MacCurdy, J. T. & Evans, H. M. Experimentelle Läsionen des Centralnervensystems, untersucht mit Hilfen der vitalen Färbung. *Berl. klin. Woch.*, 1912, No. 36.
10. Marinesco, G. Die chromatischen Reaktionen der Spinalganglienzellen bei der vitalen Färbung. *C. R. de Biol.*, 1912.
11. Monti, R. Sur les relations mutuelles entre les Éléments dans le système nerveux central des insectes. *Arch. d'Anat. Microscopique*, 1913, 15, Fasc. 2/3.
12. Müller, E. Untersuchungen über die Anatomie und Entwicklung des peripheren Nervensystems bei den Selachiern. *Arch. für mikroskopische Anat.*, 1913, 81, H. 4.
13. Rachmanow, A. Beiträge zur vitalen Färbung des Zentralnervensystems. *Folia neuro-biol.*, 1913, 7, 750–771.
14. Schrokogoroff, J. J. Die Mitochondrien in den erwachsenen Nervenzellen des Zentralnervensystems. *Anat. Anzeiger*, 1913, 43.
15. Szüto, A. von. Zur mechanischen Morphologie der Nervenelemente. *Anat. Anzeiger*, 1914, 47, No. 6/7.
16. Van Herwerden, W. Nisslsche Körner der Ganglienzellen. *Berl. klin. Woch.*, 1913, No. 39.
17. Zander, —. Neue Stützen für die Neurontheorie, *Verein für wissenschaftl. Heilkunde*, Königsberg, 18 März, 1912. (Review in *Folia neuro-biol.*, 1913, 7, 406.)

NOTES AND NEWS

THE present number of the BULLETIN, dealing with physiological psychology, has been prepared under the editorial direction of Professor R. P. Angier, of Yale University.

AT Wellesley College Miss Ivy Campbell has been promoted to the grade of instructor in psychology.

AMONG the professors who, in protest against the arbitrary removal of a number of members of the faculty, have resigned their positions in the University of Utah is Dr. Joseph Peterson, professor of psychology.

PROFESSOR W. V. BINGHAM has accepted the professorship of psychology in the Carnegie Institute of Technology at Pittsburgh. A new departure will be the establishment of a bureau of mental tests, for research and for co-operation with the authorities in charge of admissions, with the employment bureau, and with the department of student health. Professor Bingham will remain at Dartmouth College during the summer as director of the summer session.

AT a general meeting of the New York Academy of Sciences, on March 22, Professor Raymond Dodge lectured on "Incidence of the Effect of Moderate Doses of Alcohol on the Nervous System." The lecture was followed by a reception at the American Museum of Natural History.

THE Illinois State Civil Service Commission announce an examination for the position of psychologist at the Lincoln State School and Colony at a salary of $100 to $150 a month with maintenance. The examination is open to men and women over 25, and to non-residents of Illinois. Full information regarding the place and scope of the examination may be obtained on application to the Commission, at Springfield, Ill., on or before April 22.

AT the seventh annual meeting of the Minnesota Psychological Conference, which was held at the University of Minnesota on April 2, the following papers were read: Tests of Reading, B. F. Pittenger; Tests of Writing, F. L. Whitney; Tests of Arithmetic, A. Gullette; The Psychology of Expression, J. S. Gaylord; Monocular Depth Perception, R. C. Lodge; Mental Tests and Their Relation to School Standards, E. R. Collins; Measurement of School Work, J. L. Stockton.